(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: 0 159 301
A1

(12) EUROPEAN PATENT APPLICATION

(21) Application number: 85850105.9

(22) Date of filing: 26.03.85

(51) Int. Cl.⁴: H 01 Q 3/34
H 01 Q 13/10

(30) Priority: 17.04.84 SE 8402140

(43) Date of publication of application:
23.10.85 Bulletin 85/43

(84) Designated Contracting States:
CH DE FR GB IT LI NL

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(54) Electrically controlled aerial array with reduced side lobes.

(57) An electrically controlled aerial array for microwave signals comprises a plurality of aerial elements in the form of wave conductors (V1, V2, ...) provided with broadside slits or slots (S_{11}, S_{12}, ... S_{21}, S_{22}, ...). Each of the conductors (V1. V2, ...) is provided on its inside with a ridge (R1, R2, ...) of given configuration, and for each wave conductor the ridge has a given dimension such that different wave conductor wavelengths are obtained. Similarly, the mutual spacing (d_1, d_2, ...) of the broadside slits is different for different wave conductors. The positions of the grid lobes in the radiation diagram of the aerial array are thus upset and a reduction of the side lobe level may be attained.

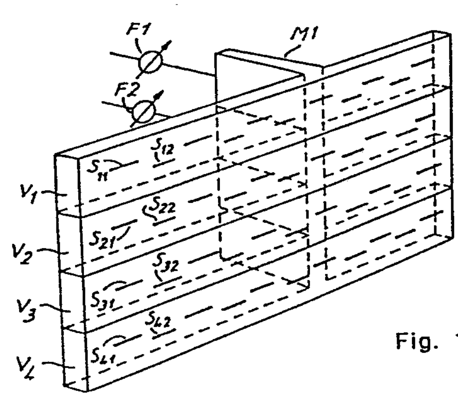

Fig. 1

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ELECTRICALLY CONTROLLED AERIAL ARRAY WITH REDUCED SIDE LOBES

TECHNICAL FIELD

The present invention relates to an electrically controlled aerial array, i.e. an aerial with a main lobe which may be controlled by varying the phases in the included aerial elements. Such an aerial is used in radar reconnaissance equipment for example.

BACKGROUND ART

An aerial array of the kind intended here comprises a plurality of aerial elements configured as rectangular wave conductors lying parallel. In particular, the radiation openings in the elements are formed as so-called broad side slits, i.e. longitudinal slits along the wider surface of each wave conductor in the aerial array. It is already known to make the aerial lobes controllable in a plane at right angles to the longitudinal direction of the wave conductors by placing phase shifters in the feed path to each conductor, e.g. according to GB-B1.577.939. alternatingly above and below the centre line of the wave conductors, the illumination function will be phase modulated along the aerial aperture, i.e. along the wave conductors. This gives rise to large side lobe peaks in the aerial array radiation diagram.

It is known to solve this problem by using radiation openings and elements that lessen or eliminate the occurrence of periodical disturbances in the aperture. For example, edge slits may be used instead of broadside slits, see "Low-Sidelobe Radar Antennas" by H. E. Schrank from "Microwave Journal", July 1983 p 109 ff. Edge slits are difficult to master from the electrical design aspect, particularly due to the strong electromagnetic connection between them, and it is therefore desirable to retain broadside slits to obtain good side lobe suppression.

DISCLOSURE OF INVENTION

The object of the present invention is to achieve an electrically controlled

aerial array of the kind mentioned in the introduction, using broadside slits as radiation elements, the aerial diagram for which shows substantially suppressed side lobes. The invention is characterized as will be seen from the characterizing portion of claim 1.

BRIEF DESCRIPTION OF DRAWINGS

The invention will now be described in detail, with reference to the accompanying drawings, where Figure 1 illustrates an aerial array with a construction known per se, but with further distinguishing features in accordance with the invention;

Figure 2 illustrates parts of two aerial elements included in the aerial of Figure 1;

Figure 3 is a cross section of an aerial element according to Figure 2; and

Figures 4 and 5 are radiation diagrams.

BEST MODES FOR CARRYING OUT THE INVENTION

The aerial array in Figure 1 comprises a plurality of aerial elements (4 elements in the Figure) in the form of rectangular wave conductors V1, V2, V3 and V4 lying parallel along their respective long narrow sides. Feed wave conductors M1 and M2-M4 (the latter three being concealed in the Figure) are each connected to one of the wave conductors V1-V4. Each wave conductor is provided with radiation openings in the form of longitudinal slits, S_{11}, S_{12}, ... on the wave conductor V1, S_{21}, S_{22} on the wave conductor V2, S_{31}, S_{32}, ... on the wave conductor V3 and S_{41}, S_{42}, ... on the wave conductor V4. All the slits or slots shown are so-called broadside slits, i.e. uniformly wide slits or slots made in the wider face of the respective wave conductor. The end portions of the feed wave conductors M1-M4 which are attached to the wave conductors V1-V4 have a feed opening (not illustrated in Figure 1) through which electromagnetic field energy, e.g. within the X band, is fed to each wave conductor V1-V4. The other ends of the feed wave conductors are connected via suitable input feed elements to the phase shifters F1-F4 (F3 and F4 being concealed in Figure 1) for controlling the phase of the field fed in, relative to a reference phase, e.g. the phase of the field to the wave conductor VI.

The use of broadside slits or slots with uniform element spacing d ($d=d_1=d_2=$, ..) according to Figure 2 gives rise to side lobe peaks in the aerial array radiation diagram, the height of the peaks depending on the directing angle. A radiation diagram is illustrated in Figure 4, in a plane parallel to the wave conductors and through the lobe maximum when the direction is 20^0 from the direction of the normal. The side lobe peaks are so-called grid lobes corresponding to the element spacing 2d. If the slits S_{11}, S_{12}, ... S_{21}, S_{22} ... etc in the wave conductors V1-V4 had mutually differing element spacing $d_1=d_2=$ ... instead, the grid lobes from the individual wave conductors V1-V4 would occur at different places in the radiation diagram and would not be added to each other to form the prominent peaks (S_1 S_2) in Figure 4. According to the invention, different element spacing is achieved by changing the wavelengths of the individual wave conductors.

Figure 2 illustrates a portion of the aerial array in Figure 1, portions of two wave conductors being depicted. The slits S_{11}, S_{12}, and S_{13}, S_{14} in the wave conductor V1 have the mutual spacing d_2 and the slits S_{21}, S_{22}, S_{23}, S_{24} etc in the wave conductor V2 have the mutual spacing $d_2=d_1$. To attain the intended reduction of the side lobe peaks in Figure 4, the wave conductor wavelength λ varied such that λg is different for each of the conductors V1-V4. This is described below in connection with Figure 3. Different spacings d_1, d_2 between the slits of the different wave conductors V1-V4 are obtained as a consequence.

Figure 3 is a cross section of a wave conductor VI with the slits S_{11}, S_{12}, there also being shown a part of an adjacent wave conductor V2. On its inner surface facing the slits S_{11}, S_{12} the wave conductor VI is provided with a raised portion or ridge R, situated symmetrically about the symmetrical axis C of the wave conductor. The ridge has two side walls RV1 and RV2 extending at right angles to the inner surface Y of the wave conductor in the longitudinal direction and entire length thereof. The side walls RV1 and RV2 are bridged by a wall RV3 at right angles to them. Both walls RV1 and RV2 have a height h from the surface Y. The wave conductor V1 is a so-called ridge wave conductor wavelength λg for a given wave conductor width $\underline{a}$ and height $\underline{b}$ may be varied within given limits by varying ridge height h. The height h is thus constant for a given wave conductor in the group aerial, i.e. for the wave conductor VI the height of the ridge R is equal to h_1, for the wave conductor V2 the height of the R2 is

h_2 ($h_1 \neq h_2$) and so on. Since the slit spacing $d \approx \lambda g/2$, the grid lobes may be spread out over the lobe angle interval of the aerial, thereby reducing their effect on the side lobe level.

In Figure 5 is shown a radiation diagram for an aerial array with a ridge wave conductor where this principle is utilised. The diagram in Figure 5 may be compared directly with the one in Figure 4, since apart from the ridges R1, R2 the aerials are otherwise entirely the same.

Broadside slits in aerial arrays of the type intended here have large advantages:

a) They have very low losses
b) They are simple and cheap to manufacture
c) Established and well functioning calculation methods are used.

The inventive aerial array retains the above-mentioned advantages due to the broadside slits, but with reduced side lobes.

The invention is not restricted to embrace wave conductors V1-V4, where the wave conductor wavelengths λg_1, λg_2, ... for the different wave conductors have been varied by the measures described in connection with Figure 3. What is essential in the inventive concept is that the wavelengths λg_1, λg_2 ... have been made different, which results in that the mutual spacing d_1, d_2, ... must be dimensioned so that $d_1 \neq d_2$ etc. There is thus obtained variation in the positions of the grid lobes for the entire aerial array, which causes a reduction of the side lobe level.

CLAIM

An electrically controlled aerial array comprising at least two juxtaposed aerial elements, each constituting a preferably rectangular wave conductor (V1, V2 ...), one side surface of which is provided with a plurality of radiation openings in the form of slits or slots (S_{11}, S_{12} ... S_{21}, S_{22} ...) in the longitudinal direction thereof, characterized in that for spreading the grid lobes, coming from the individual aerial elements when electrically directing the aerial, to different positions in the radiation diagram of the aerial array, the wave conductors in the aerial are implemented such that the wave conductor wavelength (λg) for at least some of the wave conductors (V1, V2) assumes mutually different values, the mutal spacing (d_1, d_2 ...) of the broadside slits or slots being different for selected wave conductors.

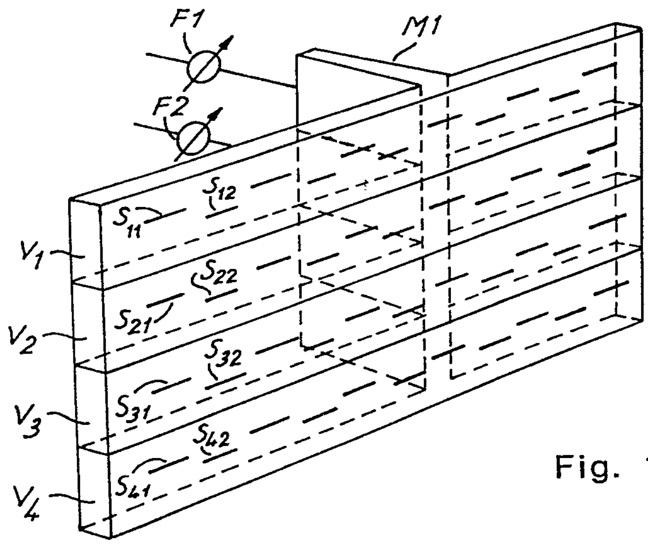

Fig. 1

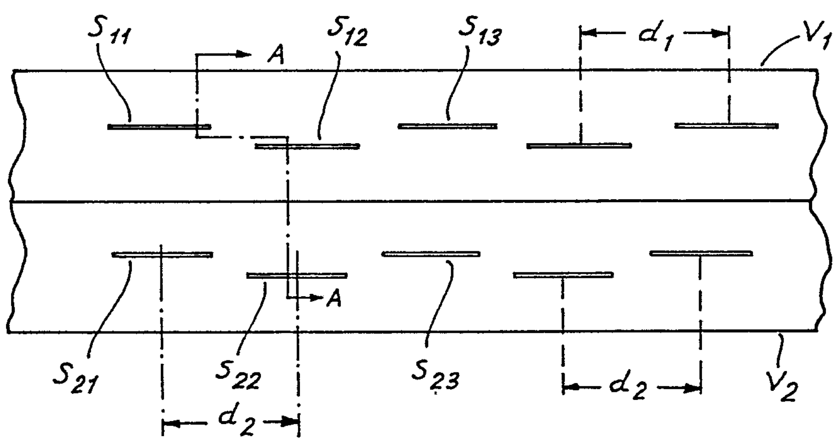

Fig. 2

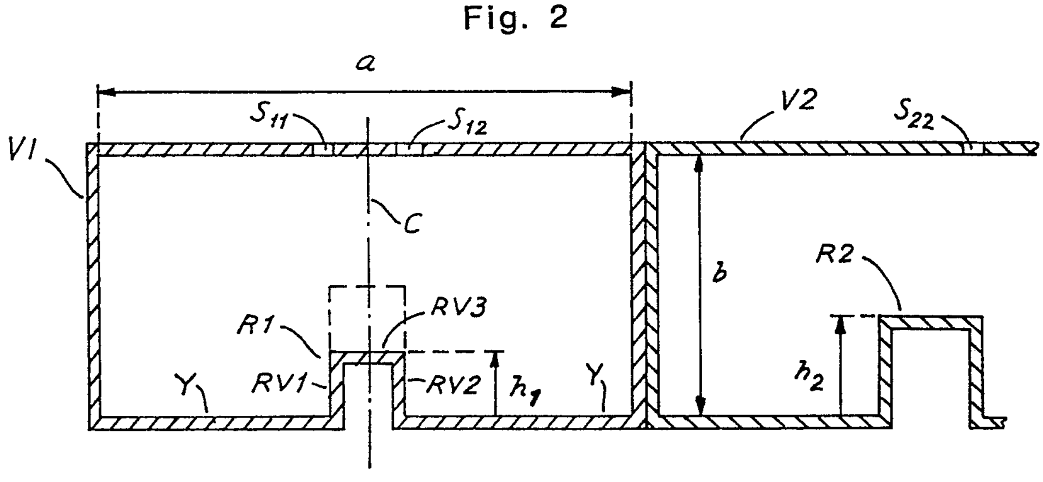

Fig. 3

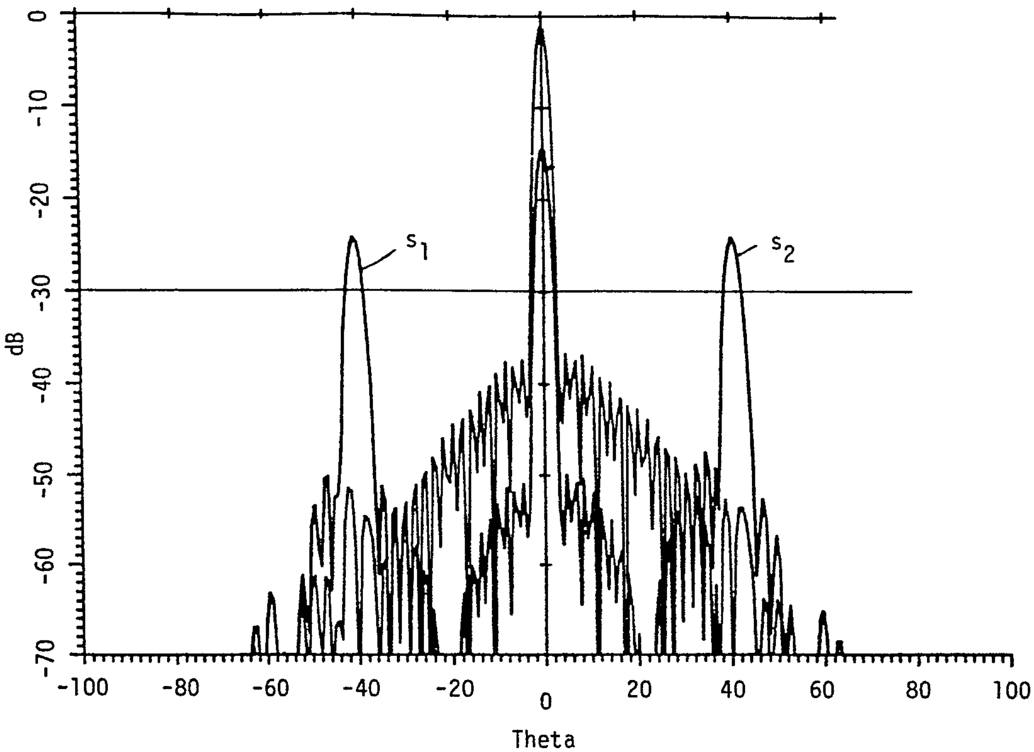
0
-10
-20
-30
-40
-50
-60
-70
dB
s_1
s_2
-100 -80 -60 -40 -20 0 20 40 60 80 100
Theta

Fig. 4

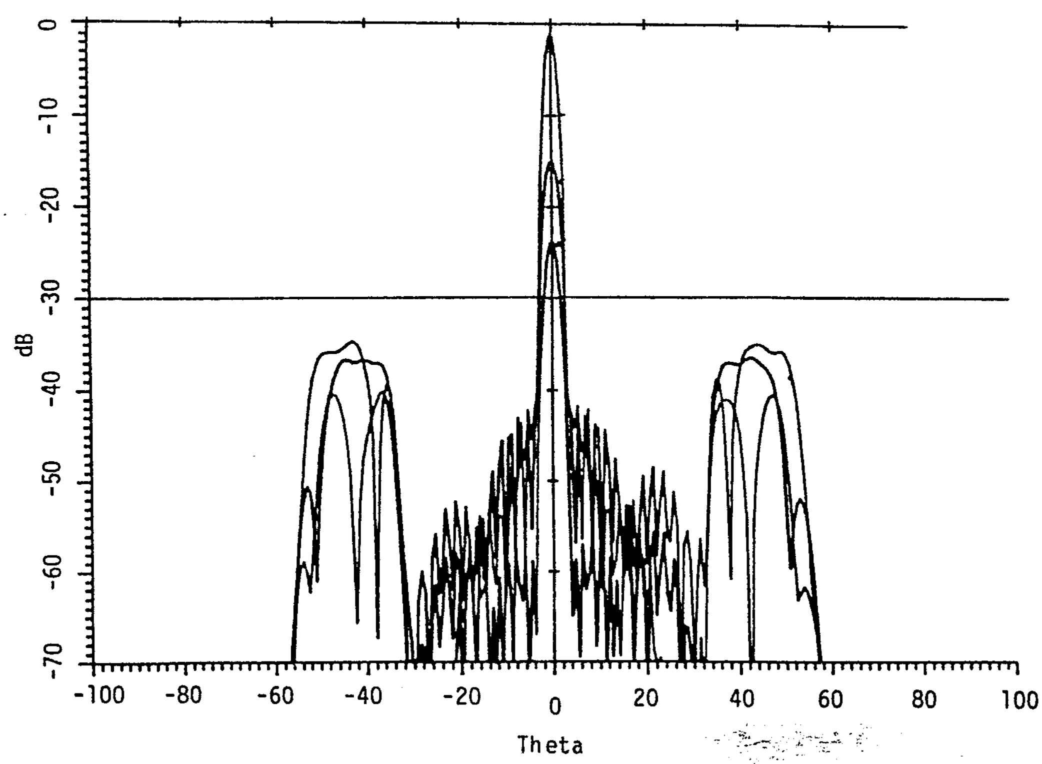
0
-10
-20
-30
-40
-50
-60
-70
dB
-100 -80 -60 -40 -20 0 20 40 60 80 100
Theta

Fig. 5

European Patent Office

EUROPEAN SEARCH REPORT

0159301 Application number
EP 85850105

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.4)
A	US-A-4 423 421 (G. PEELER et al) - - -	1	H 01 Q 3/34 H 01 Q 13/10
A	US-A-3 193 830 (J. PROVENCHER) - - -	1	
A	US-A-3 524 189 (H. JONES) - - -	1	
			TECHNICAL FIELDS SEARCHED (Int. Cl.4)
			H 01 Q

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
STOCKHOLM	05-06-1985	MAGNUSSON G.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

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